Psychological Medicine (2010), **40**, 645–655. © Cambridge University Press 2009
doi:10.1017/S0033291709990778 Printed in the United Kingdom

ORIGINAL ARTICLE

Investigating vulnerability to eating disorders: biases in emotional processing

A. Pringle[1], C. J. Harmer[2] and M. J. Cooper[3]*

[1] *Department of Experimental Psychology, University of Oxford, Oxford, UK*
[2] *University Department of Psychiatry, University of Oxford, Oxford, UK*
[3] *Isis Education Centre, University of Oxford, Warneford Hospital, Oxford, UK*

Background. Biases in emotional processing and cognitions about the self are thought to play a role in the maintenance of eating disorders (EDs). However, little is known about whether these difficulties exist pre-morbidly and how they might contribute to risk.

Method. Female dieters ($n=82$) completed a battery of tasks designed to assess the processing of social cues (facial emotion recognition), cognitions about the self [Self-Schema Processing Task (SSPT)] and ED-specific cognitions about eating, weight and shape (emotional Stroop). The 26-item Eating Attitudes Test (EAT-26; Garner *et al*. 1982) was used to assess subclinical ED symptoms; this was used as an index of vulnerability within this at-risk group.

Results. Regression analyses showed that biases in the processing of both neutral and angry faces were predictive of our measure of vulnerability (EAT-26). In the self-schema task, biases in the processing of negative self descriptors previously found to be common in EDs predicted vulnerability. Biases in the processing of shape-related words on the Stroop task were also predictive; however, these biases were more important in dieters who also displayed biases in the self-schema task. We were also able to demonstrate that these biases are specific and separable from more general negative biases that could be attributed to depressive symptoms.

Conclusions. These results suggest that specific biases in the processing of social cues, cognitions about the self, and also about eating, weight and shape information, may be important in understanding risk and preventing relapse in EDs.

Received 10 March 2009; Revised 5 June 2009; Accepted 16 June 2009; First published online 12 August 2009

Key words: Dieters, eating disorders, emotional processing, vulnerability.

Introduction

Among the numerous theoretical models developed to explain eating disorders (EDs), cognitive behavioural accounts have dominated (e.g. Garner & Bemis, 1982; Vitousek & Hollon, 1990; Fairburn *et al*. 1999). Such models have centred on the importance of disorder-specific cognitions about eating, weight and shape in their explanations of the disorders, and the focus has been on the role that these types of cognitions might play in the maintenance of the disorders. Although this is undoubtedly important, we have limited understanding of whether biases in this type of cognition exist pre-morbidly and whether they contribute to vulnerability. Moreover, there is now growing evidence that there might be other factors (unrelated to eating, weight and shape) that are important (Fairburn *et al*. 2003; Cooper *et al*. 2004; Cooper, 2005).

One area that has received particular attention is that of negative self or core beliefs (Cooper *et al*. 2004; Waller *et al*. 2007*b*). These absolute negative beliefs (unrelated to eating, weight and shape) about the self are hypothesized to have a causal role in EDs, and their modification is thought to be necessary to achieve recovery (Cooper, 2005). More recent formulations of cognitive therapy for EDs include strategies to address these negative self-beliefs (e.g. Fairburn *et al*. 2003; Cooper *et al*. 2004; Waller *et al*. 2007*a*). Negative self-beliefs are also known to be important in depressive disorders (Teasdale *et al*. 2000), and there is considerable overlap in the content of these beliefs between patients suffering from depression and EDs. Emerging evidence, however, suggests that the specific content of some of these beliefs may be different between the two disorders (Waller *et al*. 2001; Cooper *et al*. 2005; Cooper & Cowen, 2009). Like cognitions about eating, weight and shape, negative self-beliefs

* Address for correspondence: Dr M. J. Cooper, Isis Education Centre, University of Oxford, Warneford Hospital, Oxford OX3 7JX, UK.
(Email: myra.cooper@hmc.ox.ac.uk)

are thought to operate in a schematic fashion. That is to say, they form well-established knowledge structures that provide a framework for organizing cognition, enabling fast, automatic processing. Several information processing paradigms lend themselves to the investigation of these types of schematic beliefs. The emotional Stroop task (Stroop, 1935; Williams *et al*. 1996) has been used extensively to investigate eating, weight and shape cognitions in EDs, and a Self-Schema Processing Task (SSPT) developed by Markus (1977) has been proposed as a useful means of investigating self or core beliefs (Cooper, 2001).

Emotional processing has also been investigated in EDs using tasks that assess the ability to recognize facial expressions of emotion, and several studies have reported findings indicative of deficits in this skill in EDs. Zonnevijlle-Bendek *et al*. (2002) found that a mixed ED group performed generally more poorly than matched controls on a facial emotion recognition task. Anorexia nervosa (AN) patients have been reported to have poorer recognition of negative emotional facial expressions than matched controls (Kucharska-Pietura *et al*. 2004). Furthermore, a Visual Evoked Potential (VEP) study found specific impairments in the recognition of neutral, sad and disgusted expressions in addition to an increase in the N200 component response to all emotional expressions and a decrease in the P300 component response to negative emotions in patients compared to controls (Pollatos *et al*. 2008). In bulimia nervosa (BN), poorer recognition of facial expressions of surprise has been reported (Legenbauer *et al*. 2008). There are also reports of null findings in this literature (Mendlewicz *et al*. 2005; Kessler *et al*. 2006). It is highly likely that widely differing methodologies account partially for the discrepancies in these findings. In addition, in several of the studies, the effects of depression and anxiety have not been controlled for, and patients were taking selective serotonin reuptake inhibitors (SSRIs), which have been found to affect performance on this type of task (e.g. Harmer *et al*. 2003). A recent study in AN patients has addressed some of these issues by using the well-characterized Facial Emotion Recognition Task (FERT; Harmer *et al*. 2003) and considering both medicated and unmedicated AN patients (Jänsch *et al*. 2009). Unmedicated patients were found to have greater reaction times (RTs) to facial expressions of anger, fear, sadness and surprise, and there was also a positive relationship in the unmedicated group between the level of ED symptoms and the number of expressions misclassified as anger. A second study used the FERT in two non-clinical groups with high and low levels of ED symptoms (Jones *et al*. 2008). Controlling for depression, women with high levels of ED symptoms showed specific impairments in recognizing happy and neutral emotional expressions. These results provide further support for the significance of emotional processing in EDs and, importantly, for the idea that it may be relevant to development and risk.

The present study therefore aimed to consider the role of biases in processing in relation to vulnerability to EDs. A battery of tasks was selected to probe the types of non-eating-, weight- and shape-related emotional processing discussed above and recently found to be impaired in EDs but little studied in vulnerability (self-schema processing and facial emotional expression recognition), in addition to the biases in cognitions about eating, weight and shape, which have been extensively investigated in relation to maintenance of the disorders but little in relation to vulnerability (emotional Stroop). Dieters were selected for the study as it is well established that they are a vulnerable group for EDs (Crisp, 1980; Vitousek & Ewald, 1993; Gendall *et al*. 1998; Stice *et al*. 1998*b*; Jacobi *et al*. 2004). Continuum theory posits that both eating difficulties and the psychological symptoms of EDs are also present in the healthy population in a graded fashion, increasing in severity towards clinically significant cases, such that they differ only quantitatively (not qualitatively) between healthy and unhealthy populations (Nylander, 1971; Striegel-Moore *et al*. 1986; Pike & Rodin, 1991; Stice *et al*. 1998*a*). This continuum allows the establishment of a gradient of risk within a dieting group by looking at levels of subclinical ED symptoms. It has been demonstrated previously that dieters with higher levels of ED-like symptoms, labelled as symptomatic dieters, show similar biases to ED patients in the processing of ED-specific stimuli (Cooper & Fairburn, 1992). Moreover, it has also been shown in a prospective study of dieters that those who eventually go on to develop an ED have higher levels of ED symptomatology at baseline (Fairburn *et al*. 2005).

Thus, the current study aimed to investigate whether the biases demonstrated in ED patients in cognitive and emotional processing are predictive of the level of ED symptoms experienced in an at-risk group, and therefore whether they are indicative of vulnerability.

Method

Participants

Female dieters ($n = 82$) were recruited through advertisements for a study regarding attitudes to eating, weight and shape that sought healthy, female volunteers. Participants registered interest in the study by

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completing an online questionnaire, which served as a screening instrument.

Dieters were selected on the basis of a restraint subscale from the Eating Disorder Examination Questionnaire (EDE-Q, EDE-Q-R; Fairburn & Beglin, 1994), which was embedded in the online questionnaire. A cut-off of 0.8 on the EDE-Q-R was set as this represents either very frequent use of one dieting behaviour or infrequent use of several behaviours.

Volunteers who met this restraint criterion, were aged 18–30 years, native English speakers and not currently using any psychotropic medication were then screened for current and lifetime history of Axis I disorders using the Structured Clinical Interview for DSM-IV (SCID; First *et al*. 1996) either face-to-face or by telephone.

Of the 571 females who completed the online screening questionnaire, 218 met the study criteria. Ninety-three of the suitable volunteers agreed to be interviewed using the SCID and to participate in the psychological testing. Ten volunteers were later excluded as they met criteria for an Axis I disorder and one volunteer did not complete the psychological testing.

The study was approved by the institutional ethics committees.

Psychological testing

Negative self-beliefs

SSPT. This task consists of four sets of personality/self words (matched for length and frequency): negative ED relevant (e.g. evil, repulsive), negative depression relevant (e.g. numb, excluded), generic negative (e.g. hostile, bossy) and generic positive (e.g. honest, pleasant). The negative ED-relevant words and the negative depression-relevant words were selected from a factor analytic study in which patients with an ED, patients with depression and healthy controls rated their self-belief in a large number of self/personality words (Cooper & Cowen, 2009). The negative and positive words were taken from Anderson (1968). Words were presented in a random order in the centre of the screen for 500 ms. Participants were asked to decide whether the presented word applied to them or could be used to describe them and to respond as quickly and accurately as possible by pressing labelled keys ('me', 'not me') on the keyboard.

Emotional processing

FERT. This is an emotional expression recognition task featuring the six basic emotions (happiness, sadness, fear, anger, disgust and surprise) taken from the Ekman & Friesen (1976) Pictures of Affect series. The expressions have been morphed between 0 (neutral) and 100% (full emotion) intensity of the emotion in 10% increments using techniques described by Young *et al*. (1997). Four examples of each emotion are presented at each intensity, in addition to each face (total of 10 individuals) being presented in a neutral expression, giving a total of 250 stimuli presentations. Stimuli were presented in random order on a computer screen for 500 ms, followed immediately by a blank screen. Participants were asked to categorize the emotions by pressing labelled keys on the keyboard. Data from two participants were excluded due to technical failures during the task.

Cognitions about eating, weight and shape

Emotional Stroop. This task is a computerized version of an emotional ED-relevant Stroop. Four sets of emotionally relevant words were used: weight words, shape words, eating words and depression (social threat)-relevant words. Each set of emotionally relevant words had a corresponding set of neutral control words, matched for length and frequency; control words were also grouped into sets with neutral themes (transport, communication, household items and landscape). The weight, shape and eating words were drawn from Cooper & Fairburn (1992), and the social threat words were drawn from Munafò *et al*. (2006). Each word was presented once in each of the three colours used (red, green and blue) and remained on screen until participants made a response using a microphone connected to the computer. In addition to this overt version, a masked version of the task was used in which the words were presented for 14 ms followed by a string of random non-alphanumeric characters of the same length as the word and presented in the same colour ink. The words were always presented in blocks and an emotional block was always followed by its control block, but the order of the emotional blocks and the order in which the masked and overt versions were presented were rotated. Only correct responses were included in the analysis. The results were analysed as interference scores calculated as: (emotional – neutral)/neutral (e.g. Turken & Swick, 1999).

Measures

Participants also completed the 26-item Eating Attitudes Test (EAT-26; Garner *et al*. 1982) to assess the level of subclinical ED symptoms. This measure has been used extensively not only to identify those suffering from an ED but also to identify those at risk and to profile ED symptoms in analogue studies of non-clinical populations. The Hospital Anxiety and

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Depression Scale (HADS; Zigmond & Snaith, 1983) was used to assess depressive and anxious symptoms and the National Adult Reading Test (NART; Nelson, 1982) was used to measure verbal IQ.

Statistics

Regression analyses were used to explore the relationships between task variables and the level of ED symptoms as measured by the EAT-26. Given the large number of potential predictors, separate regression analyses for each task (SSPT, FERT, emotional Stroop) were performed initially. This allowed the selection of predictors of ED symptoms from each task for entry into the final regression analysis, which included predictors across all the tasks. Extraneous variables that could be associated with task performance and EAT-26 score [age, body mass index (BMI), depression (as measured by the HADS-D), anxiety (as measured by the HADS-A) and IQ (as measured by NART)] were entered into the initial regressions as control variables. A frequent criticism of this type of research is that it is difficult to differentiate between biases that are predictive of ED symptoms and those that are predictive of depressive symptoms. We therefore also conducted the analyses using the HADS-D score as the dependent variable. As all the analyses were exploratory in nature, the backwards stepwise procedure was chosen with the removal criteria set at 0.05.

We also wanted to explore whether there were significant interactions between different types of biases and therefore tested for moderation between emotional processing, negative self-beliefs and ED-specific cognitions. Where significant predictors were identified in the initial regression, moderation was testing using the method described by Baron & Kenny (1986). Each of the interactions was tested separately, and significant interactions were then entered into the final regression model.

There were a few missing data in the SSPT, and these were imputed using the closest match method as suggested by Elliott & Hawthorne (2005).

Results

Sample description

The mean age of the sample was 20.44 (S.D. = 2.73) years. BMI (mean 22.11, S.D. = 3.07), depressive (HADS-D: 2.87, S.D. = 2.23) and anxious symptoms (HADS-A: 7.06, S.D. = 3.25) were all in the normal range, as was IQ (NART: 114.93, S.D. = 5.66). Mean dietary restraint (EDE-Q-R) was 1.81 (S.D. = 0.93) and, importantly, for a healthy but at-risk group, ED symptoms were in the normal range (11.66, S.D. = 7.43).

Predicting vulnerability to eating disorders (EAT-26)

Initial multiple regressions for separate tasks

SSPT. Both RT to endorse ('me') and RT to reject ('not me') ED-relevant personality and characteristic words were significant predictors of EAT-26 score, as was age (Table 1).

FERT. The percentage of faces that were incorrectly classified as angry and the percentage of neutral faces that were accurately classified were both significant predictors of EAT-26 score, as were age and anxiety as measured by the HADS-A (Table 1).

Emotional Stroop. The interference score for shape words in the masked condition was a significant predictor of EAT-26 score, as were age and anxiety (Table 1).

Interactions

There was significant moderation of information processing biases in eating, weight and shape cognition by negative self-beliefs with an ED words endorsement RT × masked shape interference score interaction [$\beta = -0.19$, $t(78) = $ S.D. $= 2.05$, $p = 0.04$]. This interaction indicated that masked shape interference scores were more strongly predictive of ED symptoms in a group that was faster to endorse ED-relevant words (Fig. 1).

There were no other significant interactions in terms of moderation between emotional processing, negative self-beliefs or information processing biases in eating, weight and shape cognitions.

Final regression model

Using all the significant predictors from the initial regressions, the best-fit regression model consisted of six predictor variables and explained 32% of the variance in EAT-26 scores (Table 2).

Predicting depressive symptoms (HADS-D)

Initial multiple regressions for separate tasks

SSPT. The number of depression-relevant personality and characteristic words endorsed ('me') was a significant predictor of HADS-D score, as were age and anxiety (Table 3).

FERT. RTs to classify happy emotional expressions, the percentage of fear, disgust and happy emotional expressions that were correctly classified and the

https://doi.org/10.1017/S0033291709990778 Published online by Cambridge University Press

Table 1. *Predicting vulnerability to eating disorders (EAT-26 score): initial regressions for individual tasks*

Self-Schema Processing Task (SSPT)			Facial Expression Recognition Task (FERT)			Emotional Stroop		
	$R^2 = 0.21$ $F(3, 78) = 6.79^{**}$			$R^2 = 0.25$ $F(4, 73) = 6.13^{**}$			$R^2 = 0.23$ $F(3, 77) = 7.63^{**}$	
	β	sβ		β	sβ		β	sβ
ED words rejection ('not me') RT	**0.01***	**0.27***	**% misclassifications anger**	**0.67***	**0.27***	**Masked Shape Interference**	**17.42***	**0.21***
ED words endorsement ('me') RT	**0.004***	**0.22***	**% neutral faces accurate**	**1.20***	**0.32***	**Age**	**1.06****	**0.39****
Age	**1.02****	**0.38****	**Age**	**1.13****	**0.42****	**Anxiety (HADS-A)**	**0.61***	**0.26***
Depression (HADS-D)			**Anxiety (HADS-A)**	**0.52***	**0.22***	Depression (HADS-D)		
Anxiety (HADS-A)			Depression (HADS-D)			BMI		
BMI			BMI			IQ (NART)		
IQ (NART)			IQ (NART)			Unmasked Eat Interference		
No. of ED words endorsed ('me')			% of misclassifications happy			Unmasked Weight Interference		
No. of Depression words endorsed ('me')			% of misclassifications sad			Unmasked Shape Interference		
No. of Positive words endorsed ('me')			% of misclassifications fear			Unmasked Depression Interference		
No. of Negative words endorsed ('me')			% of misclassifications surprise			Masked Eat Interference		
Depression words endorsement ('me') RT			% of misclassifications disgust			Masked Weight Interference		
Depression words rejection ('not me') RT			% of misclassifications neutral			Masked Depression Interference		
Positive words endorsement ('me') RT			% happy faces accurate					
Positive words rejection ('not me') RT			% sad faces accurate					
Negative words endorsement ('me') RT			% fear faces accurate					
Negative words rejection ('not me') RT			% surprise faces accurate					
			% anger faces accurate					
			% disgust faces accurate					
			RT happy					
			RT sad					
			RT fear					
			RT surprise					
			RT anger					
			RT disgust					
			RT neutral					

EAT-26, 26-item Eating Attitudes Test; ED, eating disorder; RT, reaction time; HADS-D, Hospital Anxiety and Depression Scale – depression subscale; HADS-A, Hospital Anxiety and Depression Scale – anxiety subscale; BMI, body mass index (weight/height^2); NART, National Adult Reading Test; β, unstandardized beta; sβ, standardized beta. β coefficients are given for all the variables that contributed significantly to the model in the backwards regression model (criteria for removal $p > 0.05$).

The results are shown from the initial regression analyses for each of the emotional processing tasks; these initial analyses were used to select predictors for the final analysis. For each of the tasks, all of the task variables for that task were entered into these regressions in addition to the control variables. Significant predictors are highlighted in bold.

* $p < 0.05$, ** $p < 0.01$.

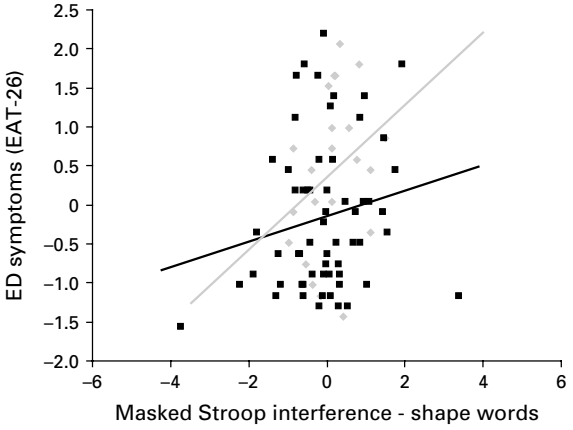

Fig. 1. Moderation of information processing biases in cognitions about eating, weight and shape by negative self-beliefs. The graph shows the interaction between reaction times (RTs) to endorse eating disorder (ED)-relevant personality words and the interference score for shape words on the masked version of the emotional Stroop. To create the graph a median split on RTs to endorse ED-relevant words was used to create a fast RT group (●) and a slow RT group (■). Axes show *z* scores, lines show linear trends for each group.

percentage of faces that were incorrectly classified as disgust were all significant predictors of HADS-D score, in addition to age and anxiety (Table 3).

Emotional Stroop. The interference score for depression words in the masked condition was a significant predictor of HADS-D score, as well as age and anxiety (Table 3).

Interactions

There were no significant interactions between task variables that were identified as significant predictors of depressive symptoms in the initial analyses.

Final regression model

Using all the significant predictors from the initial regressions, the best-fit regression model consisted of six predictor variables and explained 58% of the variance in HADS-D scores (Table 4).

Discussion

The current study investigated biases in cognitive and emotional processing in vulnerability to EDs. The final regression model explained 32% of the variance in ED symptoms, and gave the six significant predictors of age, a bias in processing ED-relevant self and personality words, attentional bias to shape words under subliminal conditions, anger misclassification,

Table 2. *Predicting vulnerability to eating disorders (EAT-26 score): final regression model*

	$R^2 = 0.32$ $F(6, 73) = 5.71^{**}$
	β
ED words rejection ('not me') RT	**0.21***
Masked Shape Interference	**0.23***
% of misclassifications angry	**0.28***
% neutral faces accurate	**0.25***
ED words endorsement ('me') reaction time×masked shape interference interaction	**0.18***
Age	**0.37****
ED words endorsement ('me') RT	
Anxiety (HADS-A)	

EAT-26, 26-item Eating Attitudes Test; ED, eating disorder; RT, reaction time; HADS-A, Hospital Anxiety and Depression Scale – anxiety subscale; β, unstandardized beta; β coefficients are given for all the variables that contributed significantly to the model in the backwards regression model (criteria for removal $p > 0.05$).

The results are shown from the final regression analysis; the predictors from all the tasks (selected by means of the initial regression analyses) in addition to the control variables that were significant predictors in these initial analyses were entered into the model. Significant predictors are highlighted in bold.

* $p < 0.05$, ** $p < 0.01$.

accuracy at identifying neutral faces and an interaction between the biasing of ED-relevant self words and attentional bias to shape words. The model is relatively novel in demonstrating that cognitive biases other than other than those relating to eating, weight and shape are predictive of vulnerability.

In the SSPT, longer RTs to reject the ED-relevant personality and self words were predictive of subclinical ED symptoms. This is consistent with the self-schema processing hypothesis, and is thought to represent interference when trying to reject schema-relevant attributes (Markus, 1977). It is interesting that the bias was evident only in RTs rather than in the actual responses of participants, as this is at odds with previous findings using similar tasks (e.g. Markus, 1977), and suggests that that implicit measure may be a more sensitive predictor of vulnerability. No other types of personality and self words were predictive of ED symptoms, and this provides support for the idea that it is possible to identify the specific content of self schemata and therefore to differentiate between depression-relevant biases and ED-relevant biases in vulnerability. It is important to emphasize that these

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Table 3. *Predicting depressive symptoms (HADS-D score): initial regressions for individual tasks*

Self-Schema Processing Task (SSPT)			Facial Expression Recognition task (FERT)			Emotional Stroop		
	$R^2 = 0.49$ $F(3, 78) = 24.45^{**}$			$R^2 = 0.57$ $F(6, 73) = 16.23^{**}$			$R^2 = 0.47$ $F(3, 77) = 22.87^{**}$	
	β	sβ		β	sβ		β	sβ
No. of Depression words endorsed ('me')	**0.09***	**0.18***	**RT happy**	**0.002****	**0.23****	**Masked Depression Interference**	**2.33***	**0.17***
Anxiety (HADS-A)	**0.39****	**0.57****	**% fear faces accurate**	**0.03***	**0.17***	**Age**	**0.15***	**0.19***
Age	**0.16***	**0.19***	**% disgust faces accurate**	**0.06****	**0.31****	**Anxiety (HADS-A)**	**0.42****	**0.60****
ED vulnerability (EAT-26)			**% happy faces accurate**	**0.48***	**0.19***	EAT-26		
BMI			**% of misclassifications disgust**	**0.17****	**0.23****	BMI		
EAT-26			**Anxiety (HADS-A)**	**0.48****	**0.69****	IQ (NART)		
IQ (NART)			Age			Unmasked Eat Interference		
No. of ED words endorsed ('me')			EAT-26			Unmasked Weight Interference		
No. of Positive words endorsed ('me')			BMI			Unmasked Shape Interference		
No. of Negative words endorsed ('me')			IQ (NART)			Unmasked Depression Interference		
ED words endorsement ('me') RT			% of misclassifications happy			Masked Shape Interference		
ED words rejection ('not me') RT			% of misclassifications sad			Masked Eat Interference		
Depression words endorsement ('me') RT			% of misclassifications fear			Masked Weight Interference		
Depression words rejection ('not me') RT			% of misclassifications surprise					
Positive words endorsement ('me') RT			% of misclassifications anger					
Positive words rejection ('not me') RT			% of misclassifications neutral					
Negative words endorsement ('me') RT			% sad faces accurate					
Negative words rejection ('not me') RT			% surprise faces accurate					
			% anger faces accurate					
			% neutral faces accurate					
			RT sad					
			RT fear					
			RT surprise					
			RT anger					
			RT disgust					
			RT neutral					

EAT-26, 26-item Eating Attitudes Test; ED, eating disorder; RT, reaction time; HADS-D, Hospital Anxiety and Depression Scale – depression subscale; HADS-A, Hospital Anxiety and Depression Scale – anxiety subscale; BMI, body mass index (weight/height^2); NART, National Adult Reading Test; β, unstandardized beta; sβ, standardized beta. β coefficients are given for all the variables that contributed significantly to the model in the backwards regression model (criteria for removal $p > 0.05$).

The results are shown from the initial regression analyses for each of the emotional processing tasks; these initial analyses were used to select predictors for the final analysis. For each of the tasks, all of the task variables for that task were entered into these regressions in addition to the control variables. Significant predictors are highlighted in bold.

* $p < 0.05$, ** $p < 0.01$.

Table 4. *Predicting depressive symptoms (HADS-D): the final regression model*

	$R^2 = 0.58$ $F(6, 73) = 16.23^{**}$	
	β	sβ
RT happy	**0.002***	**0.21***
% **fear faces accurate**	**0.03***	**0.20***
% **disgust faces accurate**	**0.06***	**0.31***
% **of misclassifications disgust**	**0.18****	**0.21****
Masked depression interference	**2.88****	**0.21****
Anxiety (HADS-A)	**0.48****	**0.68****
% happy faces accurate		
No. of depression words endorsed		
Age		

HADS-D Hospital Anxiety and Depression Scale – depression subscale; HADS-A, Hospital Anxiety and Depression Scale – anxiety subscale; RT, reaction time; β, unstandardized beta; sβ, standardized beta. β coefficients are given for all the variables that contributed significantly to the model in the backwards regression model (criteria for removal $p > 0.05$).

The results are shown from the final regression analysis; the predictors from all the tasks (selected by means of the initial regression analyses) in addition to the control variables that were significant predictors in these initial analyses were entered into the model. Significant predictors are highlighted in bold.

* $p < 0.05$, ** $p < 0.01$.

personality and self words were ostensibly unrelated to eating, weight and shape.

In terms of facial expression recognition both the total number of neutral faces accurately identified and the number of faces misclassified as anger were significant predictors of ED symptoms. The finding that anger misclassification predicts ED symptoms is in line with earlier evidence that has demonstrated a positive relationship between the level of ED symptoms and anger misclassification in non-medicated AN patients (Jänsch *et al*. 2009). One possible explanation for the total number of neutral faces accurately identified being predictive of ED symptoms is that, with increasing levels of ED symptoms, there is an increasing tendency to identify more faces overall as neutral, and that the side-effect of this response strategy is a tendency to get more neutral faces correct. However, there was no significant relationship between the number of faces misclassified as neutral and the level of ED symptoms, suggesting that this interpretation does not explain the data. Increased accuracy for neutral emotion recognition is at odds with findings both in AN patients (Pollatos *et al*. 2008) and in volunteers with high levels of ED-like symptoms (Jones *et al*. 2008). Although the volunteers in the Jones *et al*. (2008) study are described as a non-clinical group, participants in the high symptom group of the study had a mean EAT-26 score indicative of clinically significant difficulties and several of their group reported histories of EDs. It is therefore possible that poorer recognition of neutral emotional expressions is present in illness, but that increased accuracy for neutral faces is indicative of vulnerability.

Biases in cognitions about eating, weight and shape are mostly cited with reference to the maintenance of EDs, and as cognitive theories might predict, a bias in the processing of shape-related words was predictive of ED symptoms in the emotional Stroop. This type of bias has been found previously in dieters with high levels of ED symptoms (Cooper & Fairburn, 1992). The bias was only important in the masked condition, suggesting that it is pre-attentive biases in processing that are more predictive of vulnerability. There was also an interaction between RTs to endorse ED-relevant self words and masked shape-related interference on the Stroop. This interaction indicated that the effect of increasing Stroop interference with ED symptoms was greater in those who were faster to endorse ED-related self words, suggesting that it is the combination of both strong negative self-beliefs and the biases in the processing of information about eating, weight and shape that is important in this vulnerable group.

In terms of the control variables that were entered on the basis of theoretical importance, only age and anxiety as measured by the HADS-A emerged as significant predictors. It is interesting that depression did not emerge as a predictor, as a frequent criticism of this type of research is that biases could also be explained by depressive symptoms. Moreover, in the tasks where depression-relevant stimuli were included as control variables (SSPT and Stroop), only the ED-relevant variables emerged as significant predictors of ED symptoms. As a further control we also repeated the analyses using depressive symptoms (HADS-D) as the dependent variable. Here, the final model explained 58% of the variance, with accuracy for fearful and disgusted facial expressions, RT for happy faces and the number of misclassifications that were disgust, in addition to the interference score for depression-relevant social threat words in the emotional Stroop and anxiety (HADS-A) all being significant predictors. These findings are consistent with the large body of evidence documenting negative biases in emotional processing in those at risk of depression and show a clear dissociation between those elements of the tasks that are predictive of depressive symptoms and those that are predictive of ED

https://doi.org/10.1017/S0033291709990778 Published online by Cambridge University Press

symptoms. The larger amount of variance explained in this model as opposed to the ED model is probably attributable to the very close relationship between depression and anxiety. Taken together, all of these results suggest that our findings are relatively specific to EDs.

Our final model explains 32% of the variance, and there are several factors that we have not included in the model that we hypothesize or acknowledge are important. First, there are sociocultural factors and family and life event variables that we acknowledge are important in explaining vulnerability, the inclusion of which we predict would increase the amount of variance explained. Moreover, longitudinal studies will be required to assess whether the biases seen here are predictive of change in ED symptoms over time. The present study did not include a control group of non-dieters with low scores on the EAT-26 as a correlational design was judged to be the most powerful method of investigating vulnerability. Although dieters are a vulnerable group for EDs, very few dieters will in fact go on to develop an ED (Fairburn *et al*. 2005). Dieters who demonstrate some ED-like symptoms are more at risk than other dieters (Cooper & Fairburn, 1992; Fairburn *et al*. 2005), and this enabled us to establish a gradient of risk using EAT-26 scores within our sample. Our participants did not have an ED history. In so far as those with ED symptoms are at risk of developing an ED, then it is possible that the biases we have identified here may be important in the development of a clinical ED. Further work is required to establish whether such biases predict the severity of the disorder, and its course over time in a clinical sample. It will be particularly important to establish the role of biases ostensibly unrelated to eating, weight and shape and, as in the current study, their relationship to depression.

In conclusion, these results show that the types of biases in emotional processing seen in patients suffering from EDs are also present in an at-risk (but not previously ill) group. These biases can be used to explain some of the variance in vulnerability, as they are predictive of the level of subclinical ED symptoms experienced within the group. Importantly, we are able to demonstrate that levels of depressive and anxious symptoms do not contribute to the model, and that biases in the processing of depression-relevant stimuli only are predictive of depressive symptoms. This suggests that our results are relatively specific to EDs. The contribution of negative self or core beliefs ostensibly unrelated to eating, weight and shape to the prediction of ED symptoms, measured using an information processing task, is a particularly novel finding and indicates that both the task and the construct are worthy of further investigation in relation to vulnerability to EDs and to EDs themselves.

Acknowledgements

We thank the School of Psychology, University of Birmingham for assisting in the recruitment of participants and for the provision of testing facilities, and in particular we thank Dr S. Higgs for her support. The study was funded by the Medical Research Council (MRC). A.P. is supported by an MRC studentship.

Declaration of Interest

C.H. has acted as a consultant for P1vital, Servier, Lundbeck and Merck, Sharpe and Dohme, and is on the advisory panel for P1vital.

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